Solar maximum power point tracking (MPPT)

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1. Abstract

Increasing the energy demand as developing the technology making some big challenges which technology is facing today, increasing the energy consumption increases the need of energy resources which is renewable and non-renewable energy the non-renewable energy resources not available in access amount in the nature and due to courteously usage of the non-renewable energy resources it's going to be finished in coming decades now the world is facing the big challenge which is global warming, depletion of ozone layer and environmental pollution. to overcome these challenges and energy demand technology is turning toward renewable energy resources.

Renewable energy is becoming increasingly important as more and more industrialized using solar power as opposed to fossil fuels and coal is becoming cheaper and easier to access throughout the world, yet there are still efficiency hurdles to overcome. Designing a cheap, easily modified and repairable maximum power point tracker would be a stepping stone to bringing solar power to remote parts of the globe. Once designed and made portable, these devices could be distributed through the market to enhance renewable energy output.

According to studies, MPPT tracker allows us to provide a stable supply chain and shows maximum power point tracking is effective in providing the necessary power to load. Voltage and efficiency test of the tracker showed that it increases solar panel output; maximum power point tracking has the potential to greatly impact electricity consumption in developing countries.

2. Introduction

2.1- solar power efficiency problem

Solar energy is one of the best significant and freely available in nature renewable energy sources(RES) that have been attainment better attention to meet the need of energy production over the top leading countries in renewable energy in recent years. The solar energy has highest availability compared to other energy sources in different countries region.

The volume of energy delivered to the earth in one day by the sun is enough to power the total needs of the energy of the earth for one complete year. Solar energy is clean and free of emissions since it does not produce pollutions or by-products harmful to nature. The conversion of solar energy into electrical energy has many application fields [1].

Solar to electrical energy conversion can be done in two ways which are solar thermal and solar photovoltaic. Solar thermal is similar to convert AC electricity generation by steam turbine expecting that instead of fossil fuel, heat extracted from the concentrated solar rays is used to produce steam and apart is stored in thermally insulated tanks for using during intermittency of sunshine or night time. Solar photovoltaic use cells made up silicon or certain types of semiconductor material which convert the energy observed from incident sunshine into DC electricity[2].

To make up for intermittency and nighttime storage of generated electricity into buttery is needed. Recently, Research and development of low cost flat-film solar panels increased. Thin-film devices, concentrated systems, and many innovative concepts have increased. Shortly, the costs of small

Solar-power modular units and solar power plants will be economically feasible for large-scale production and use of solar energy.

As the focus is to improve the efficiency of the solar panel. The foremost way to increase the efficiency of a solar panel is to use a maximum power point tracker (MPPT), a power electronic device that considerably rises the system efficiency. By using it operates at the maximum power point (MPP) and produces its maximum power output. Thus, an MPPT make the most of the array efficiency so falling the general system charge.

2.2. Need for renewable energy and its harnessing through MPPT

Solar energy is the main source of power generation that independent away from petroleum, coal and other dependent energy resource. The major problem with solar is conversion efficiency, poorer regulation, and high installation cost. Studies are going on in this area to develop a better and more efficient control mechanism and provide better control. Hence the overall installation cost of the photovoltaic charging system reduces. The challenging researches work going in this area is the motivation behind the project.
Solar energy is abundantly free and open in nature that has made it potential to harvest it and utilize it appropriately. Solar energy is the type of energy sources that can be an individual generating system or can be a grid-connected generation unit depending on the availability of the grid nearby. Thus it can be used to produce power in rural areas where the availability of grids is very rare.
Solar energy is a form of energy that is directly and readily available from the sun convert to electrical energy, which is the best form of energy without any climatic change crisis. This conversion can be achieved with the help of a solar power plant.
To store solar energy charging systems are required to efficiently charge the battery with the lesser time charging. A maximum power point tracking process is mandatory to improve the efficiency of the solar panel. The most commonly used known are [1] hill-climbing, [2] fractional open circuit voltage control, [3] perturb and observe (P&O), [4] incremental conductance (INC), Neural network control and fuzzy control, etc. these algorithms are varying due to simplicity, effectiveness, merging speed, sensor required and cost. The most commonly used algorithm based on current and voltage are incremental conductance (INC) and perturb and observe (P&O) methods due to their simplicity, effectiveness and merging speed.

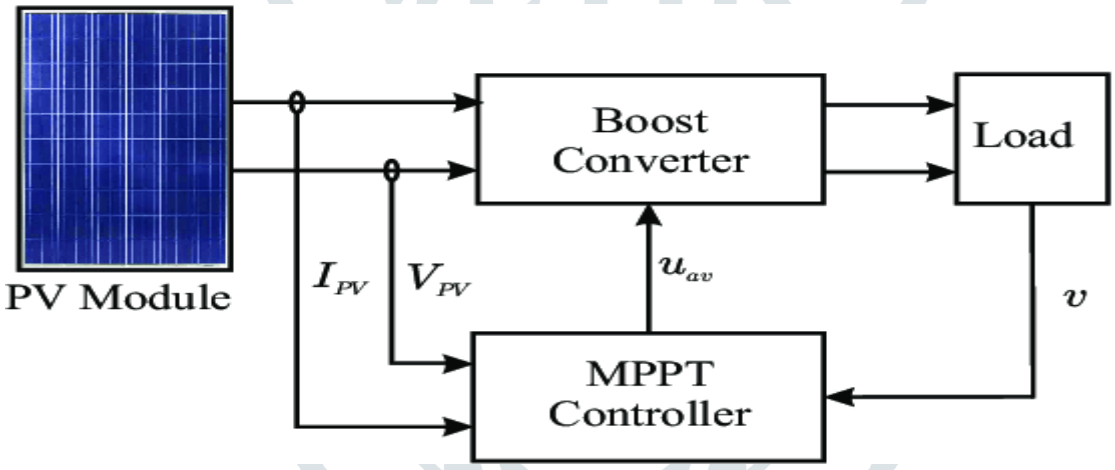

Fig.1. MPPT model

Under sharply changing in solar irradiation ratio as MPPT, varies continuously by time P&O receipts it as the variation in maximum power point of the system due to perturbation relatively than amount solar irradiation and from time to time ends up calculating incorrect MPP. Yet, this difficult gets escaped by incremental conductance method in case of the incremental conductance method algorithm of tracking takes two different trials of voltage and current to estimate MPP. Therefore, in order to high efficiency and complication of incremental conductance algorithm, it is more accurate than the P&O method. This MPPT algorithm combines with a battery charging loop to charge the lead-acid battery with different charging stages like constant current, constant voltage, float charge. So optimal is charging pattern design to charge the lead-acid battery with the three different charging stages that are constant current, constant voltage, and float charging.

2.3- solar panel photovoltaic cell

A solar panel is set and coupled gathering of photovoltaic cells, the solar sheet can be used as a section of a bigger photovoltaic system to produce and supply electricity in commercial, residential and lighting application. Solar panels use the light energy photon from the sun to generate electricity through the photovoltaic effect, the common of the modules use a wafer-based cell or thin-film cells base on non-magnetic conductive transition metals, telluride or silicon. Electrical connections are made in the series to achieve the desired output voltage and or in parallel to provide the desired current capability.
The conducting wires that take the current off may contain silver, copper or other magnetic conductive transition metals. The cell must be connected electrically to one another and the rest of the system. Individually photovoltaic panel is assessed by its DC output power in standard conditions and typically ranges from 1001 to 320 watts.

Depending on the construction photovoltaic panels can produce electricity from a range of light frequencies, but usually cannot cover the entire solar range (specifically, ultraviolet and low or diffused light). Hence much of the incident sunlight energy is wasted by solar panels, and they can give higher efficiencies if illuminated with monochromatic light

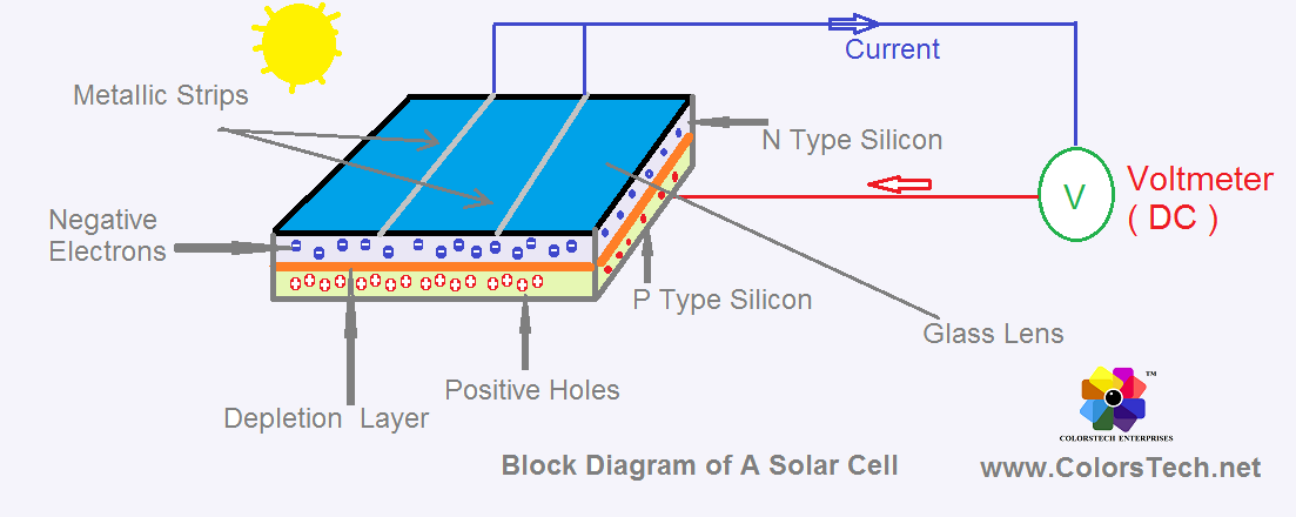

Fig.2. circuit diagram [1]

2.4. Advantages of solar panels

- ✓ The most readily available solar technology.
- ✓ They can last a lifetime.
- ✓ They required little maintenance.
- ✓ Operate best on bright days with little or no obstruction to incidence sunlight

2.5- solar cells:

A photovoltaic cell or photoelectric cell is the semiconductor device that converts the light energy to the electrical energy by the photovoltaics effect. Whenever the energy of the photons of the light is larger than the band gap, then the electron is emitted and the flow of electron creates the electric current.
However, a photovoltaic cell is different from a photodiode. In a photodiode, light falls on the n-channel of the semiconductor junction and gets converted into a current or voltage signal but a photovoltaic cell is always forward biased.

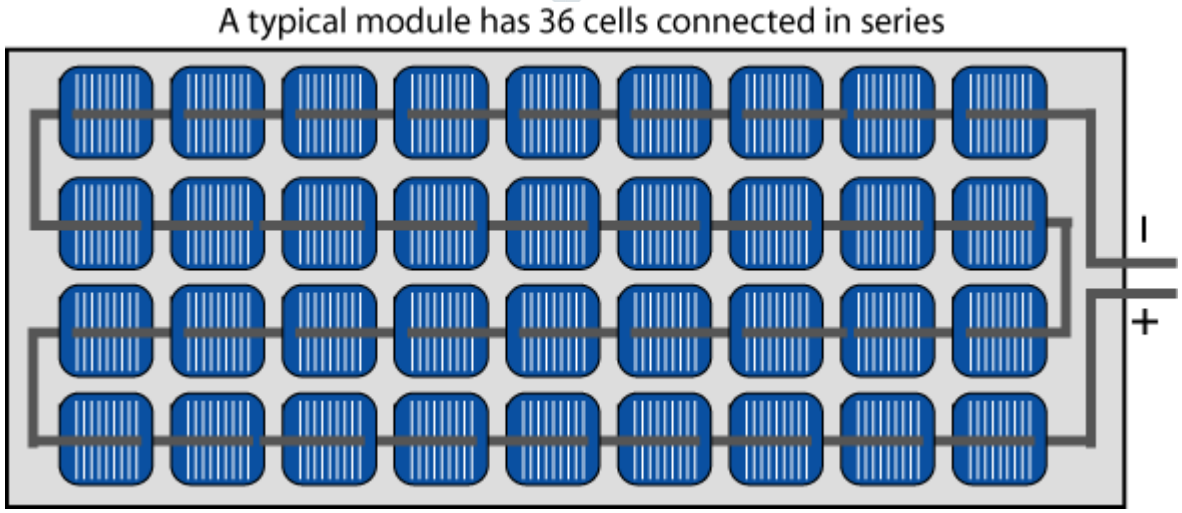

Fig.3. solar cell layout

2.5- Solar I-V and P-V characteristics:

The I-V characteristics of a solar panel are a graphical representation of the current and voltage in which of different current (I) for different voltage (V) is going to be plotted on the X&Y axis the ideal Current-voltage characteristics of a PV module is shown the fig.4

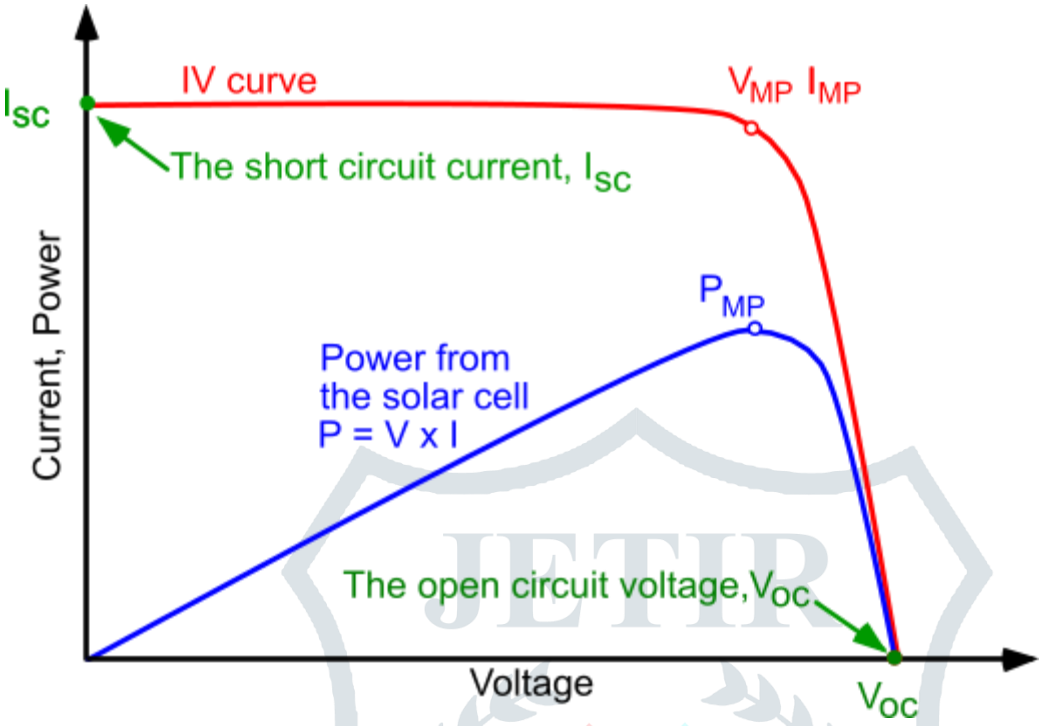

Fig 4 I-V and PV curve

3- Maximum power point tracking (MPPT):

For any assumed regular working conditions cells have only one operating point where the ideal values of the current and voltage of the photovoltaic cell result in maximum power output of the system. These values obtained relay to a certain load resistance R=V/I as quantified by ohm's low. The power p is set by P=V*I from elementary circuit principle of the amount real power transported from a device is adjusted in the system performance where the offshoot of the I-V currant and voltage curve is equivalent and opposite to the I / V ration.

These phenomena are celebrated and known as the maximum power point (MPP) of operated system under normal operating condition of system and relate to the "knee point" of the power output curve the load through the Resistance R=V/I which is closely equal to the reciprocal amount of this set point value and appeals the maximum power from the device is usually known as the characteristics resistance of the solar photovoltaic system. This is a dynamic intensity and capacity which its deviations and changes with respect to time during the period of days' dependent on the level of the rang of illumination drown from the sun by any panel, as fine as additional features from the environmental factors such as temperature, shading, moisture, and life time of the photovoltaic cell, if the internal resistance of system is lesser or higher than compered rate of the power drown from the cell will be less than the maximum accessible power which is possible to draw from the cell, and thus the photovoltaic cell will not be operate efficiently when the environmental disturbance and abnormal condition is happing as it could be ideally. Maximum power point trackers employ the Varity and different types of the controller path or rationality to search for this point and thus to allow the converter to excerpt the maximum power available from the cell.

3.1- methods of MPPT algorithm:

Maximum power point tracking (MPPT) is employed to achieve the maximum power from the system. In these applications, the load can demand more power than the PV system can deliver. There are many different approaches to maximizing the power from the Pv system, this range from the using simple voltage relationships to more complexes multiple sample-based analysis.
The MPPT techniques vary in many aspects, which might help the users to decide the system that suits their unique applications. These parameters include implementation, sensor, convergence speed, multiple local maximum, cost, application, and dependency on the array parameter. Hardware implementation is simply the type of circuit: analog or digital Sensors and their numbers affect the decision makers to decide which MPPT to use. The more precise MPPT requires more sensors (Reported issued by National Instruments 2009). Usually, it is easier to sense voltage than current. The irradiance or temperature sensors are quite expensive.
Conjunction speed is the time engaged to reach the maximum power point (MPP) for a high performance MPPT arrangement, the time engaged to meet to the essential operating voltage or current should below. The lesser time and intermittent tuning took to influence the MPP minimize power losses and maximize efficiency. The ability to detect multiple local maxima when the system is under different irradiance levels is another important parameter. The power loss can reach (70 %) under restricted shading situation if a local maximum is tracked in its place of the real MPP.
Performance cost is another parameter that concerns the users. It is usually cheaper to use an analog system than the digital system. Moreover, the number and type of sensors, using other power or electronic components, add extra cost to the system
Different MPPTs are suitable for various applications. Depending on the application, different aspects may be considered important when choosing the PV system. As an example, in space satellites and orbital stations applications that involve a huge expanse of money, the charges and complexity of the MPP tracker are not as significant as its performance and dependability. The tracker must be able to constantly track the true MPP in a lowest period of time and should not involve periodic tuning

The MPPT system might be independent or direct or dependent (indirect) on array parameters. The direct approaches use PV voltage and/or current dimensions. These direct approaches have the benefit of being self-regulating of the prior information of the PV array arrangement and factor values for their employment. Thus, the operating point is independent of irradiance, temperature, or dilapidation stages. The indirect approaches are created on the use of a record of factors that contain data of typical P–V curves of PV systems for dissimilar irradiances and temperatures, or on the use of mathematical functions achieved from experimental data to evaluate the MPPT reviews the best important characteristics of MPPT algorithm that is employed to match between different techniques.

3.1.1. MPPT methods and algorithm

it is the most used tracking algorithm and its name implies it is bases on the perturbation of the system by the increase or decrease of input voltage or by acting directly on the duty cycle of the DC/DC converter and then observing the effect on the output power of the system. Power P(k) of the solar panel is greater than the previous value of P(k-1) than the same direction of the previous disturbance is otherwise the perturbation of the preceding cycle is reversed.

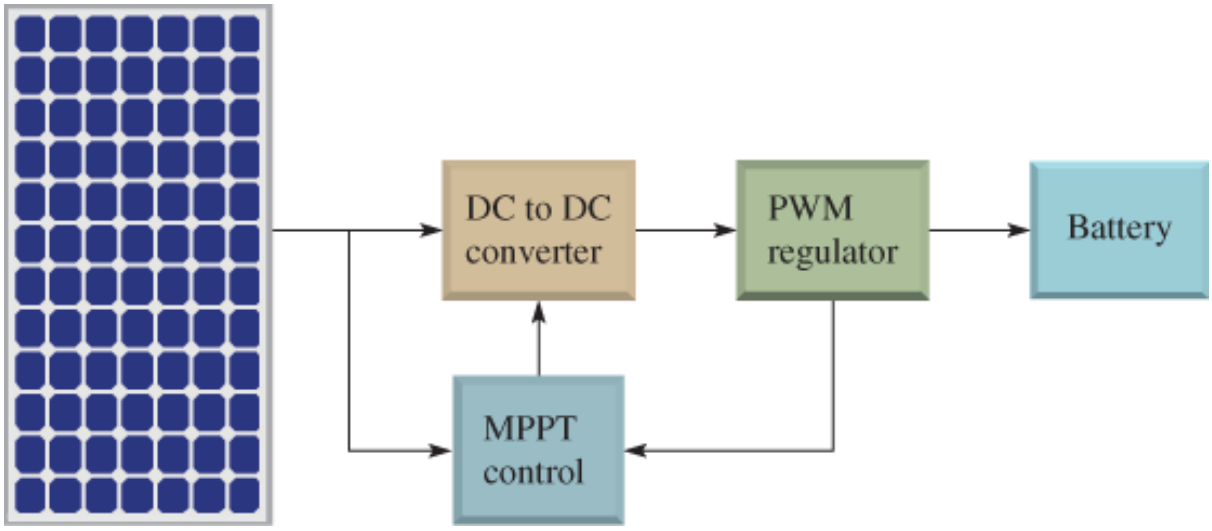

Fig.6 MPPT circuit diagram [5]

Perturb and observe is the most popular techniques. This method operates the PV at the maximum power point by varying either voltage or current and maximum power is extracted out of the solar panel. This is an impedance matching process in which the input impedance is matched with the output impedance and hence power is maximized. And the change in power is described by the equation below.

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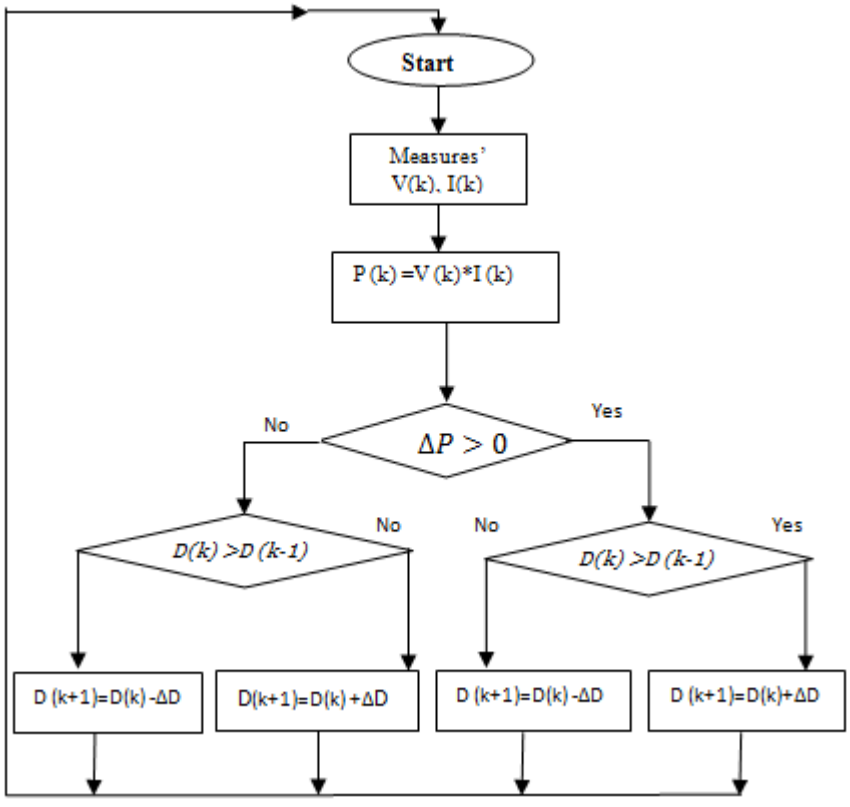

Fig.7.MPPT circuit diagram

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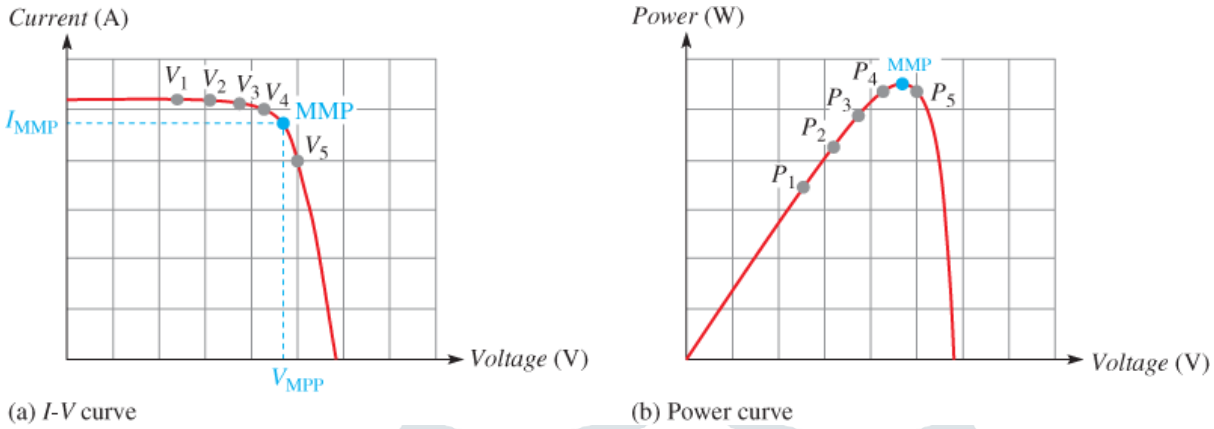

Fig.8. maximum power on the IV curve

3.1.2- Incremental conductance method:

incremental conductance equals to the conductance range of the solar photovoltaic than maximum power point (MPP) is touched. Here is the important sensing element such voltage and current which is detected simultaneously. Therefore, the error from the performance of system in order to varies in irradiance is rejected and the must reach its optimal running condition to deliver maximum possible output. However, the complicity and difficulty in system arrangements with the consideration of all expenses charges of the employment also increase.

Complicity and the all the other expenses charge for the system due to system arrangement implementation and maintenances increasing which may be appropriate for an extremely complicated and large generation system.

This is the cause perturb and observe (P&O) and incremental conductance algorithms are the best commonly used algorithm. Currant to perceive the result of power change this method needs more calculation but can trail and perceive the algorithm.

Under abruptly change in the irradiance level as maximum power point change constantly, perturb and observe (P&O) receiving it as a change in maximum power point (MPP) due to external disturbance farther than that of range isolation and most commonly resulting in calculating wrong and improper maximum power point MPP. But, this challenges and deficiency which result poor output can be escapes by incremental conductance. In this technique, the algorithm proceeds two samples of voltage and current to maximize power taken by the solar module. Due to the effectiveness and complexity of the incremental conductance algorithm as compare to perturb and observe. Like the P&O algorithm, it can result oscillation and disturbance oscillation in power output so these are two advantage of incremental over perturb and observe method. So in implementation and system management, maintenance and performance to achieve high efficiency this method utilizes incremental conductance of the photovoltaic array to calculate the sign of change in power concerning voltage and current in the system, this controller maintains the voltage till the insolation of sunshine is changes.

3.1.3- Fractional short circuit:

Fractional short circuit is the type of algorithm that can result negatively under varying atmospheric conditions temperature, shading moisture, the currant in the maximum power point IMMP is approximately very closely related to the short circuit currant (ISC) of the PV array IMMP=K2Isc, where the K2 is defined as the proportionality constant. As same as the fractional open circuit voltage (Voc) techniques K2 has to be determined according to the PV array in use. The constant K2 is generally originating in range 0.78 to 0.92, measuring short circuit currant Isc during operation is problematic. In additional switch usually has to add

to the power converter to periodically shot the PV array so that I can be measured using the current sensor.

3.1.4- Fuzzy logic

Microcontrollers have made using fuzzy logic control for MPPT over a decade. Fuzzy logic controllers have the advantage of working with imprecise inputs not needing an accurate mathematical model and handling nonlinearity.

Conclusion

A renewable energy system can be made for residential or industrial application. The result suggests that, based on maximum power tracking efficiency, the perturb and observe method is the most commonly used algorithm among all trackers has the great potential to be very competitive with the other method if it properly optimized for the given hardware.

As the studies are investigated regarding all four methods of MMP controller among those the all the is P&O (perturb and observe method) is most commonly used, efficiency is high, and designing the perturb and observe method is easy. The output of all the method is depending on the ways of designing the algorithm which good designing will provide better output power and increase the output in some amount

Aside with this for many application, it can be appropriate device to select for application like robots, electric vehicles and etc. wherein electric vehicle efficiency increase and a driving range of the vehicle also going to increase respectively also it helps to reduce the cost of the panels which can be preferred to go for low range.

Apart from that, a system such as this can be deployed easily with little concern about adopting at home or business's electrical wiring to take advantage of solar energy. Much surplus energy generated by a system such as this to be sold to the grid in a policy known as net marketing. After accomplishing the model of the PV module the model of DC/DC converter and MPPT control system are confined with it to complete the PV simulation system with MPPT function. Voltage and execution efficiency for each MPPT algorithm can then by simulated under different weather voltage. Therefore, it was seen that using perturb and observe MPPT techniques increase the efficiency of the photovoltaic system by a considerable amount of respect to the earlier output power.

Developing such a system will greatly help to reduce the air pollution, prevent the depletion of natural resources such as fuel, oil, coal, it also prevents from deforestation and improves environmental health conditions suitable for human and another living being on earth. From an economic point of view, it will play an important role in reducing the amount of money required for power generations from fossil fuel.

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